Decay of Interference due to Electric Forces

Arnold J. Dahm, Case Western Reserve University, DMR 0071622

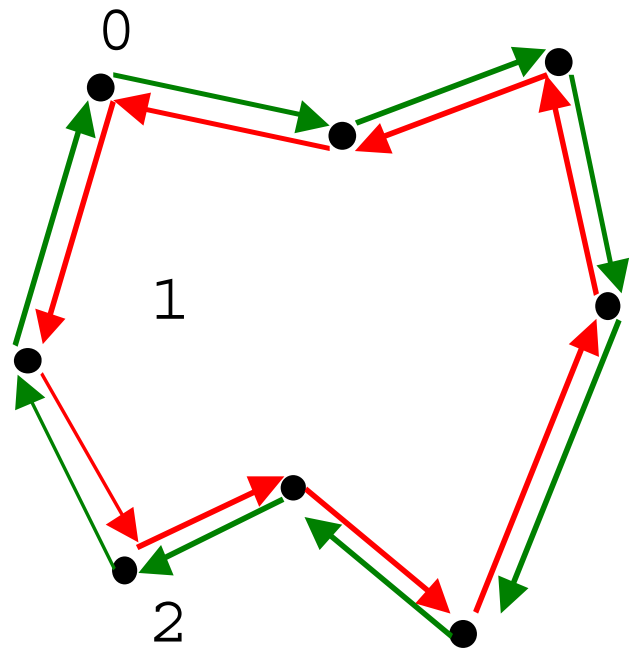
An electron interferes with itself in the same way a light particle does in forming a diffraction pattern.

Electrons traverse closed paths by scattering from particles. Beginning at zero an electron goes around the part in both clockwise (green path) and counter clockwise (red path) directions at the same time. When it returns to zero it interferes with itself constructively. This results in an enhanced probability of returning to the starting point.

The electric force from other electrons cause the electron paths to bend. This force varies in time, and is different along a given segment, say 2-3,for the two paths. This destroys the interference.

We determine the decay of the interference by measuring the resistance of the electrons in a magnetic field.

Electrons on a helium surface interact strongly, and their motion is highly correlated. The result is that the electric field varies at the maximum sound velocity, ω, in the electron gas. We measured the time for the decay of interference, τ, to be inversely proportional to this speed (see next slide).



An electron traverses a closed path in both directions at the same time and interferes with itself at the starting point.

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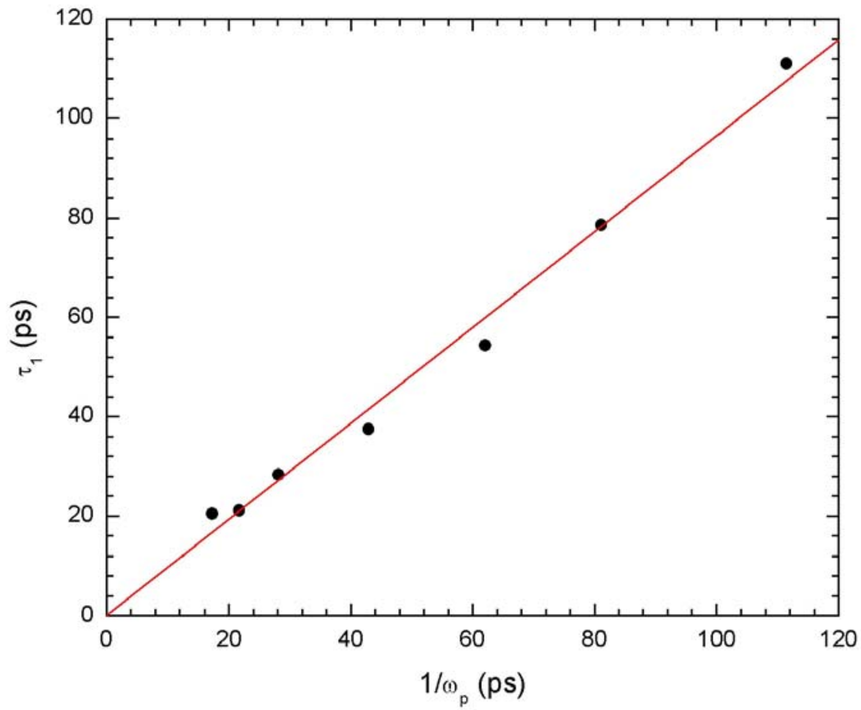
Educational:

Undergrads: Michael Salem,
Jason Radachy
Justin Morgan
Grad student: Mehmet Goksu
Post-docs: Nam-Jung Kim

Collaborators:

Theorists
Grad student: Damir Hermann
Professor: Harsh Mathur

We supervise an undergraduate student on a year-long senior project each year.
An NSF-REU student is hired each summer.
I advised engineering students in a writing course on related science.



The time for decay of interference varies linearly with the inverse of the sound velocity ω of the electron gas.

Dephasing due to Interaction Between Electrons
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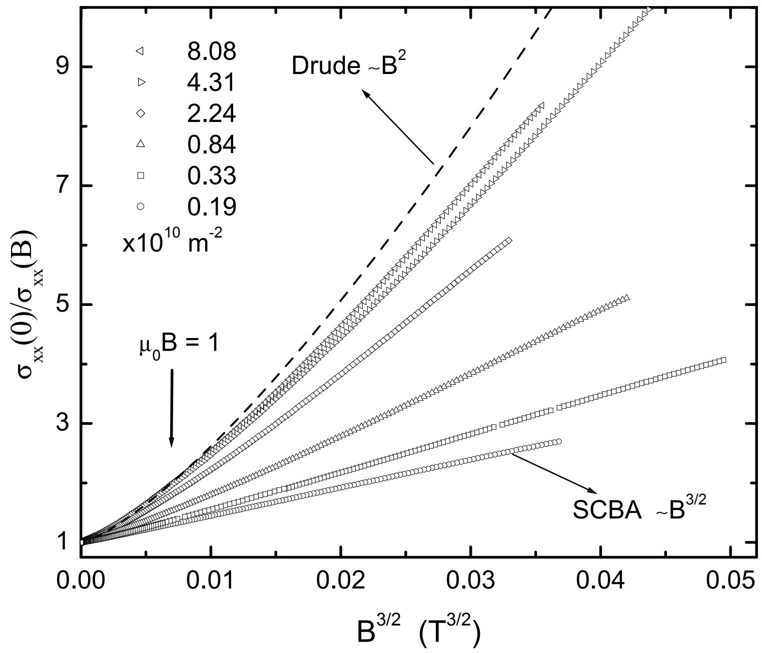
Strong interactions between electrons are of importance in a number of systems such as high temperature superconductivity. These interactions are particularly strong for electrons confined above a liquid helium surface since there is no background positive charge nearby.

In a magnetic field electrons have energies in a narrow range, called Landau levels. Interactions between electrons broaden these energy levels to a range Δ.

The resistance of electrons in a magnetic field B is linear in $B^{3/2}$ for B larger than Δ/μ; μ is the magnetic moment of an electron. The deviation from this linear behavior is a measure of the electron-electron interaction.

The strength of the interaction increases rapidly as the average separation of electrons is decreased by increasing the density (see next slide).



Curves of resistance versus magnetic field. Higher curves represent increasing electron density.

The resistance in a magnetic field varies linearly in $B^{3/2}$ for low electron densities. Large deviations are observed as the density is increased.

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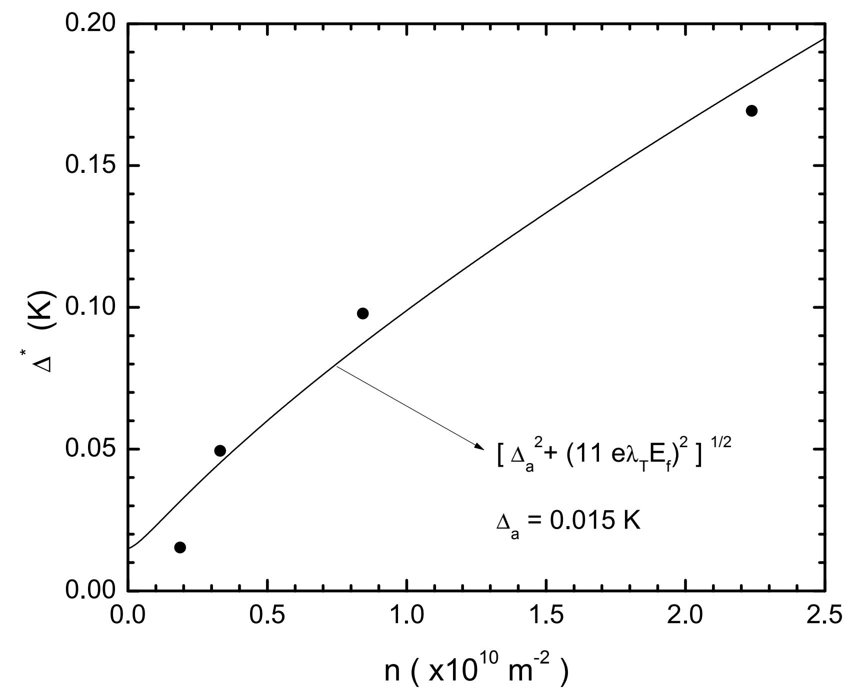

The strength of the electron-electron interaction as a function of electron density. The interaction strength increases rapidly as the density increases.